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From the Ground up: Assessing Bacterial Diversity in the Air Space of an Urban Park

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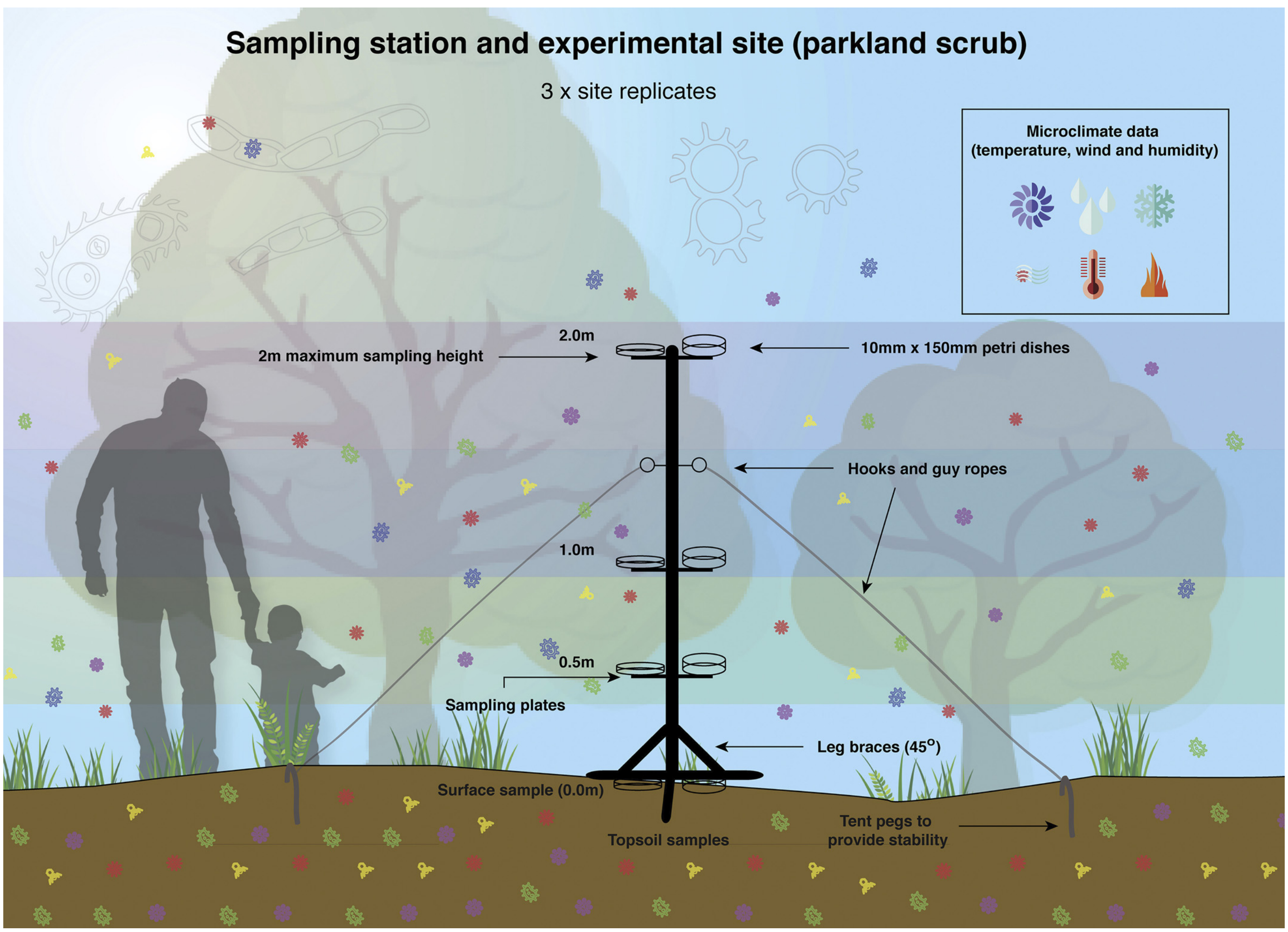
Emerging research has linked exposure to diverse airborne microbial communities to healthy human immune systems.[1] But few studies have examined how communities of airborne microbes (aerobiomes) vary over time and space[2]; none are known to have investigated whether these communities change with height from the ground. A recent proof-of-concept study in *Environmental Health Perspectives* described how the diversity of airborne bacterial communities decreased from ground level to 2 m in height in an urban park, noting that the makeup of the communities also varied, depending on height.[3]

"Exposure to a diverse set of microbes from our environment trains our immune systems to respond appropriately to pathogens," says Graham Rook, a professor of medical microbiology at University College London who was not involved in the study. Lack of exposure to bacterial diversity has been associated with autoimmune diseases,[4] allergies,[5] Alzheimer's disease,[6] and inflammatory bowel disease.[7]

Airborne microbial communities are important for human health because our skin and mucous membranes are exposed to them every day.[8] Yet the community structure of the aerobiome remains little known, says lead study author Jake Robinson, a doctoral student in microbial ecology at England's University of Sheffield. An earlier study comparing forest and grassland areas found that elements of the local environment likely drive aerobiome structure.[9] "But we wanted to know how the airborne bacterial communities varied over vertical space because, due to height differences, children may be exposed to different microbes than adults," Robinson says.

He and his team chose an urban park in Adelaide, Australia, that consists of about 700 hectares of gardens, woodlands, and playing fields. The researchers set up sampling stations in three randomly selected plots of scrub habitat, defined as parkland with semi-mature trees. At each station, they constructed a stand resembling a hat rack with petri dishes mounted at ground level and at



Vertical stratification sampling stations captured a snapshot of bacterial diversity at different heights from the ground. Image: Robinson et al. (2020); DOI: 10.1289/EHP7807.

0.5, 1, and 2 m above the ground. These levels were chosen to roughly represent the height of a jogging stroller, a 4-year-old child, and an adult, respectively.

On three different days the team left the petri dishes open for 6–8 hours to passively sample the aerobiome. They also collected soil samples. The environmental conditions during the sampling were warm and dry.

Back in the lab, the researchers extracted DNA from the samples and amplified the region coding for the 16S rRNA gene. This gene is present across all bacteria and can be used to distinguish between different organisms.[10] Software tools clustered the millions of gene sequences and taxonomically identified sequences down to the level of bacterial genus. To quantify bacterial diversity, the team used the Shannon Diversity Index, which uses both species richness (the number of species in a population) and species evenness (the abundance of each species in a population).[11]

The index scores declined by roughly one-third from soil level to 2 m above ground. The highest score was found in one of the soil samples. Genera that occurred in both air and soil tended to decline with height above ground. Approximately 84% of taxa in the lower air samples and 76% of upper air taxa were also found in soil. In addition, the community composition of bacterial genera varied widely at different heights. The investigators estimated that sampling height explained 22% of the variation in aerobiome makeup in the study.

Notably, this study sampled a small area for only 3 days and did not analyze bacterial DNA down to the level of species and strain. That information would be important "in order to determine whether the organisms they were looking at are the ones that might end up in our guts," Rook says. In addition, aerobiomes vary across habitat types, different weather conditions (e.g., windy vs. calm days), and concurrent activity levels (e.g., kicking a ball vs. sitting).

"The finding that microbial communities vary with height is important because we breathe hundreds of millions of microbes every day," says Emily Flies, a research fellow in health ecology at the University of Tasmania in Australia. "That exposure during early development is crucial to children's immune systems. But most aerobiome sampling is done at two meters above ground, so this study indicates that if we want to research what kids are breathing, we need to be sampling at half a meter above ground."

Flies adds that, with more research on how microbial exposure translates to health, investigators may find ways to optimize human exposure to health-promoting biodiverse microbes in greenspaces. This study suggests that greenspaces where people can sit or lie on the ground might facilitate more biodiverse microbial exposures, she says, but further research is needed to confirm these findings and to determine whether and how those microbial exposures affect human health.

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